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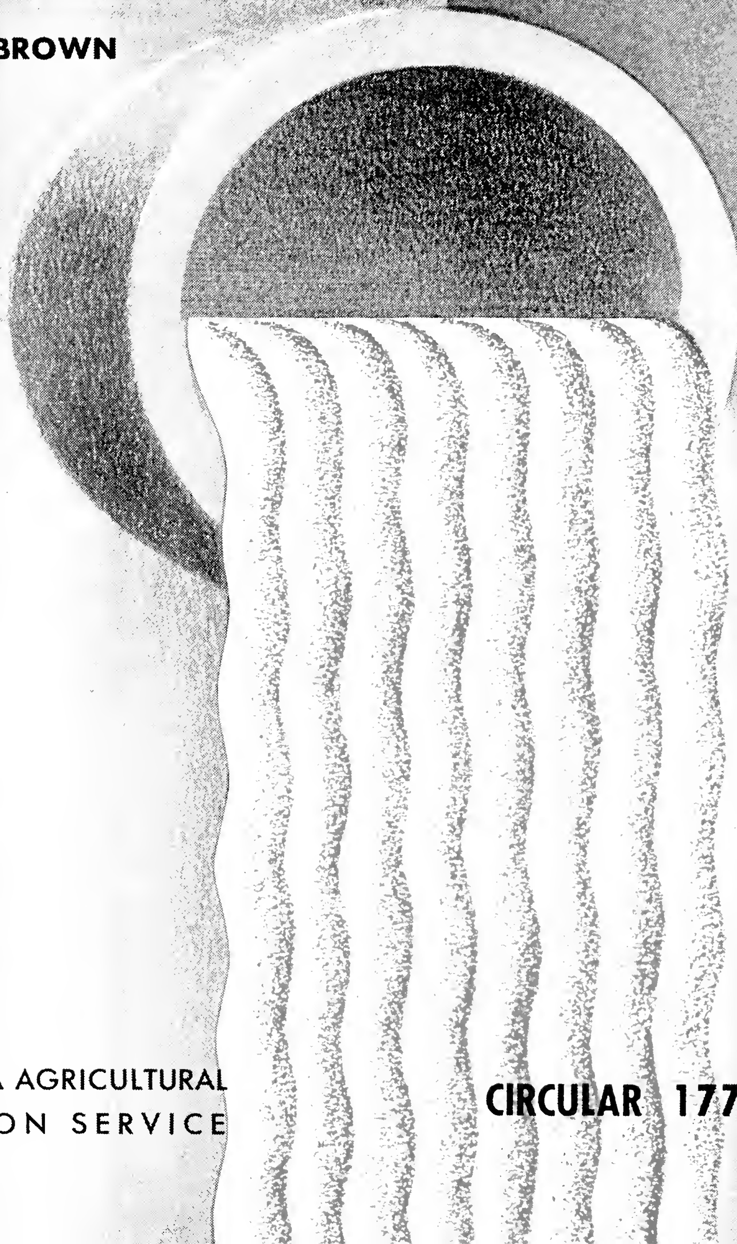
IRRIGATION METHODS
to conserve soil and water
ON STEEP LANDS

LLOYD N. BROWN

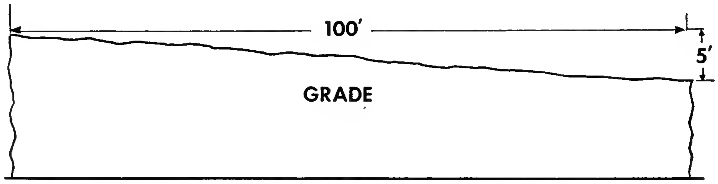


CALIFORNIA AGRICULTURAL
EXTENSION SERVICE

CIRCULAR 177

STEEP-LAND

Soil Erosion Can Be Serious on Land with a Slope of 2% or More



Per Cent Slope is the term given the fall (or rise), expressed in feet, for each one hundred feet of horizontal distance. A five per cent slope, then, falls (or rises) five feet in each hundred.

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JUNE, 1951

IRRIGATION METHODS

to

Save Your Soil

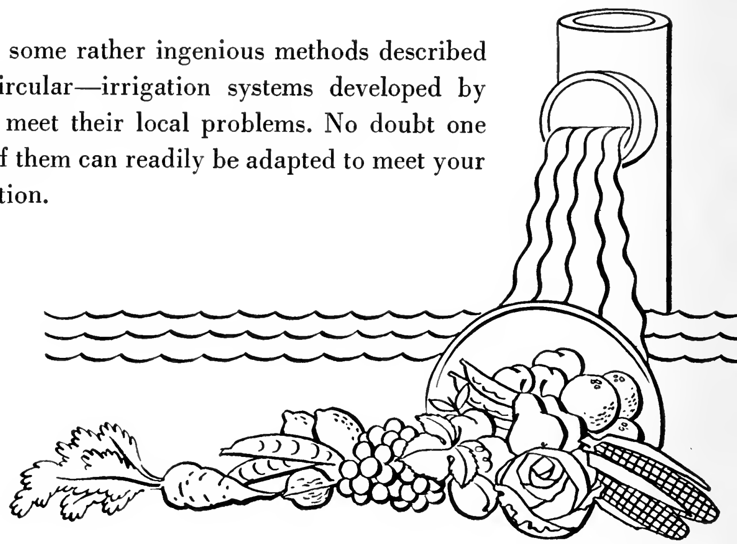
Save Your Water

Produce Better Crops

Whether yours is an irrigated orchard, vineyard, farm, or city lot—if it's on a grade of two per cent or more, you probably have an irrigation problem. When trees, vines, and other crops need water, it should be properly applied. Soil erosion must be prevented to keep land productive.

The susceptibility of land to erosion during irrigation is governed by several factors: the method used, the rate at which water is applied, the cover on the soil, and the texture of the soil.

There are some rather ingenious methods described in this circular—irrigation systems developed by people to meet their local problems. No doubt one or more of them can readily be adapted to meet your own situation.



Before Discussing Steep Lands . . .

A FEW FUNDAMENTALS

CALIFORNIANS have developed many highly specialized irrigation methods—these to meet the state's great variation in water supply, topography, soil, climate, and crops.

Even though this circular deals with irrigation in a very general, informal, and nontechnical fashion, there are five terms which are commonly used and which should be understood. They are:

Field Capacity: This is the amount of water held by the soil shortly after irrigation, provided there is free downward movement through the soil. In other words, when irrigation water has completed its downward and horizontal movements, the soil is at field capacity.

Wilting Point: When the soil reaches the stage where there is insufficient moisture to prevent plants from wilting, it is known to be at the wilting point.

Acre-Inch: The amount of water necessary to cover one acre of ground with one inch of water explains this term. Otherwise, the equivalent of a one-inch rainfall.

Head: The amount of irrigation water delivered, and variously measured as cubic feet, gallons, or miner's inches.

Per Cent Slope: The term given the fall (or rise) of lands in feet, compared to horizontal distance. (See page 2.)

Soil Is a Water Reservoir for Plants

The purpose of irrigating is to fill the soil to *field capacity* to the depth occupied by the plant roots. It usually takes roots from one to several weeks to reduce this irrigated soil to the *wilting point.*

Soils Vary in Water-Retention

Coarse or sandy soils will hold much less water at field capacity than fine or clay soils. Loam will hold about twice as much as sand, and clay will hold about twice as much as loam. Generally speaking, if the capacity of sand is One, loam would be Two, and clay Four. Expressed as actual percentages of the weight of the dry soil: sand, about seven per cent; loam, about fourteen per cent; and clay, about twenty-eight per cent.

Water Available to Roots

Most plants can obtain all the water they need if the soil moisture is in the range from field capacity to approaching wilting point. For most soils, the wilting point is about one half of the field capacity.

Necessary Frequency of Irrigation

It has been indicated that it is usually necessary to irrigate twice as often on sands as on loams, and twice as often on loams as on clay soils. This is in order to keep a water supply available to plants at all times. Assume, then, that you have three plants of equal size growing in large pots of sand, loam, and clay. *These plants will all use water at the same rate, regardless of the texture of the soil in which they are growing.* Therefore, the water in the sand will be used up sooner than in the loam; the water in the clay will last longer than that in the loam.

When several days are required to irrigate an area, irrigation should be started in order that it be completed so that the last plants receive water before they wilt. In other words, irrigation should start—possibly before absolutely necessary—in order that the last plants be irrigated before they get too dry.

OF IRRIGATION

When to Start Irrigating

Most crops have a definite pattern of water usage. Spring starts with relatively small amounts used. Summer brings peak need, with a lessening during fall. For example, an orchard might require these amounts of water during these months:

April	1 Acre-Inch
May	3 Acre-Inches
June	5 Acre-Inches
July	6 Acre-Inches
August	6 Acre-Inches
September	3 Acre-Inches
October	1 Acre-Inch

Another factor in timing the first irrigation is the amount of rainfall during the previous winter. In the case of permanent crops, such as orchards, a light winter's rainfall makes an earlier irrigation necessary, to bring the soil which plant roots occupy to field capacity. For annual crops, the soil which the roots will occupy should be at field capacity before planting.

Soil Is Either WET or DRY

Rain on a dry field wets down a definite distance. The soil underneath remains dry. So it is with irrigation water—it wets to field capacity, adjacent ground remaining unchanged.

Wet the Entire Root Area

An irrigation should wet all of the soil which the plant roots occupy. Rain is, of course, the ideal—because it falls evenly and wets the entire area. But this perfection can be approached if these warnings are heeded: Furrows, if spaced too far apart, will not wet all of the soil between them. Insufficient water in basins will not seep deeply enough. Sprinklers must be left at each setting long enough to allow proper penetration.

Caution! Don't Over-Irrigate

As most of the soils discussed in this circular are of limited depth—underlain by bedrock, hardpan, or claypan—over-irrigation is likely to waterlog the soil just above these impervious strata. This water may also seep to the base of the slope in such volume that it could drown out trees. Citrus crops and avocados are particularly susceptible; slight over-irrigation can cause gummosis in citrus and root rot in avocados.

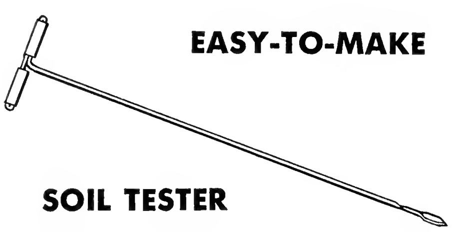
Variations in Soils

Some soils will not give up the usual one half of the water they contain at field capacity. They must be irrigated more frequently. In the Sierra Nevada foothills there are red soils that provide good examples of these exceptions.

Variations in Crops

Some crops, *when young*, require a higher percentage of soil moisture. This is because the young plants have underdeveloped root systems. These should be given lighter, more frequent irrigations.

EASY-TO-MAKE



SOIL TESTER

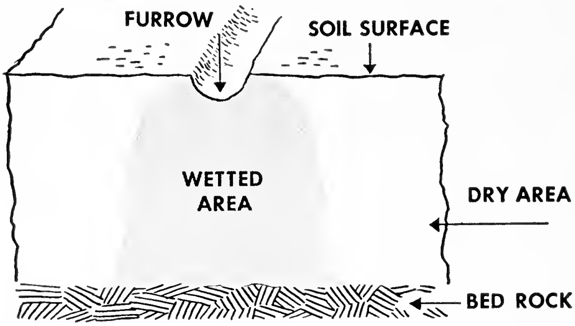
A length of three-eighths-inch rod, sharpened at the end, will be of great help in learning to what depth water (either rain or irrigation) has penetrated. Press it into the wet ground. It will stop at the dry level. Care must be taken to avoid deception when it is used in rocky soil.

FURROW IRRIGATION

Here are Some Principles

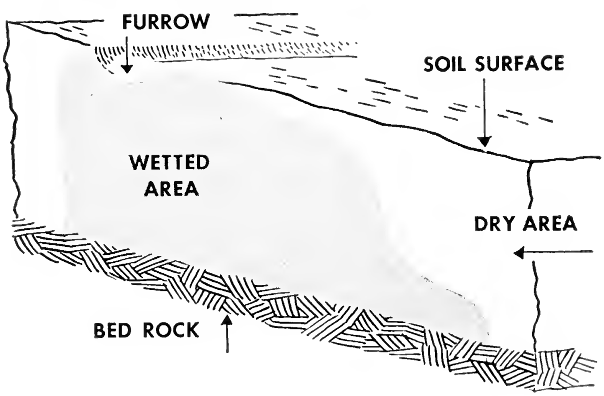
Below are two illustrations of furrows—one running from top to bottom of the slope, the other across the slope.

Furrow Down the Slope



Two hazards go with this type of irrigation. If the slope is too steep, soil erosion can be a serious problem. If the furrows are not placed at frequent intervals, the entire mass of soil may not be irrigated.

Furrow Across the Slope



This furrow should be flat enough so that soil does not wash—usually less than a two per cent slope. Normally furrows should be about ten feet apart, but experience can help to determine proper distances.

# of Steep-Lands Irrigation

Success Comes with Change in Irrigation Technique

This orchard of olives in Butte County was originally irrigated almost straight down the slope—left to right in the photograph—on a grade of five per cent to six per cent. Growth and production were unsatisfactory. It was suggested that the furrows be run across the slope, as now indicated. Growth was vigorous, and crops increased considerably.

The soil is about eighteen inches deep. It is stony, and underlain by bedrock. With the old method of irrigation, a relatively small part of the soil was wetted. Now the water seeps down and wets the root areas. *Caution:* Overirrigation waterlogs shallow soil. It should be avoided. This method is not usually recommended for citrus or avocado crops.

FURROW IRRIGATION

A Skillful Down-the-Slope Irrigation on a 4% Grade

Here is a fine young grove of oranges in Riverside County that utilizes furrow irrigation on a slope that normally would be considered dangerously steep for this technique. However, there has been no evidence of erosion. The photograph was taken following the first irrigation after the furrows were made.

Just prior to making the furrows, a heavy covercrop was worked into the soil. Remnants can be seen in the foreground. A very small amount of water was turned into each furrow to "set" the soil, to prevent washing with large heads during subsequent irrigations. This irrigation has sprouted the next covercrop, and the soil will soon be full of small roots which will make it still more resistant to erosion. Note that the furrows pictured are at frequent enough intervals to assure wetting all the soil to field capacity.

Once again, caution: The most critical point of irrigation under these conditions is the first usage of the furrows. Water must flow very slowly and in small amounts.

"Homemade" Devices Regulate Flow, Avoid Undue Washing

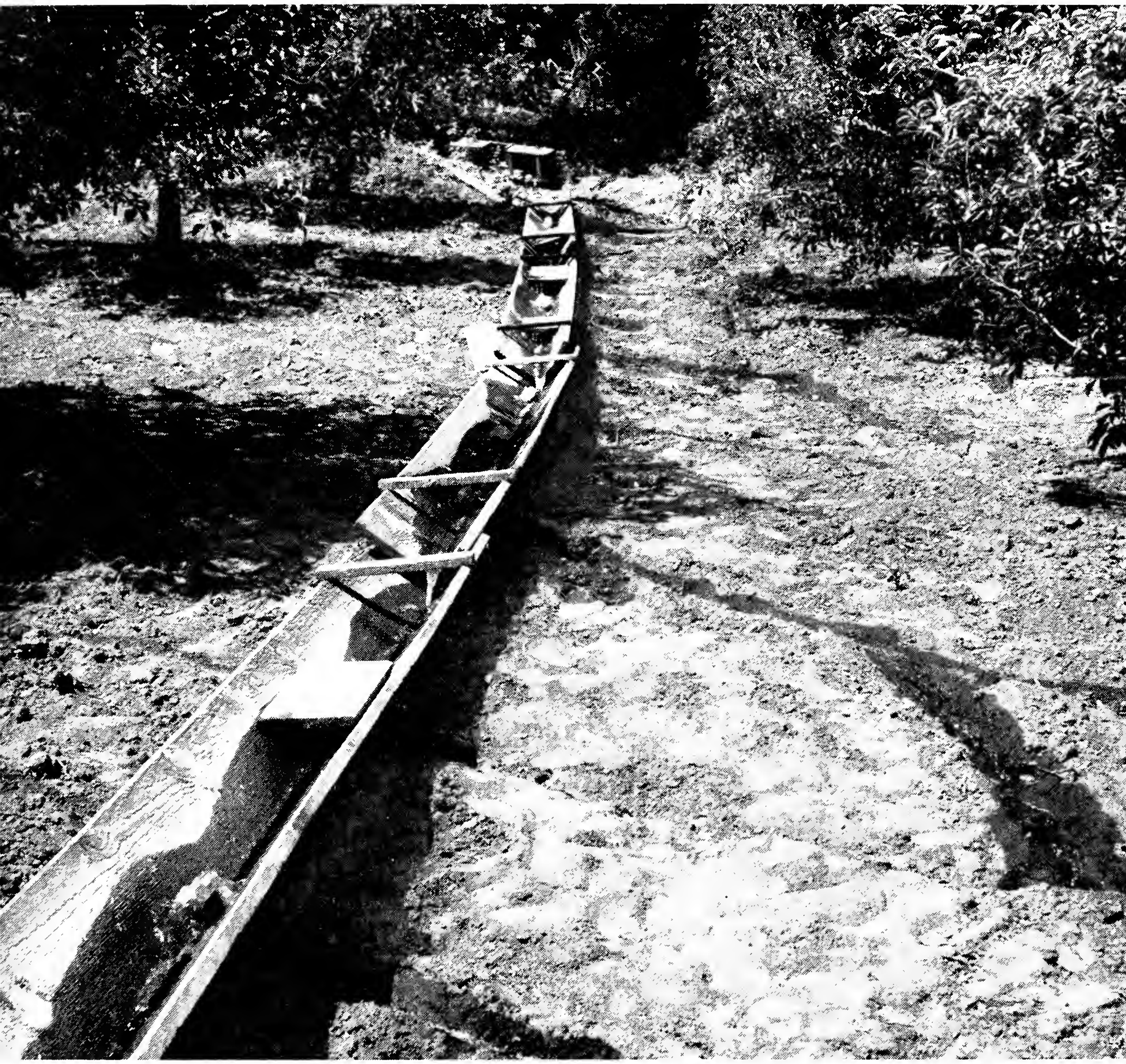
Native ingenuity comes to the rescue in devising methods and using materials at hand to get the job done. A case in point is the use of such items as rocks, burlap, paper, short boards, slats, weeds, and other materials to regulate the amount of water admitted to a furrow.

The upper photograph shows a pear orchard in El Dorado County, and the use of burlap dams. They can be seen in the ditch at the right. The lowest one is placed to divert the stream to the left and into a furrow. (*Note:* If another burlap dam had been placed midway between the two nearest ones, there would have been less erosion.) They usually are about ten inches square. Occasionally steep supply ditches are lined with burlap.

The photograph at left shows the supply ditch running from upper left to lower right. Small rocks are used to regulate the height of water in the ditch, and the directing of water into the irrigation furrows.

FURROW IRRIGATION

The Use of Flumes to Contr



The grade of about twenty per cent in this pear orchard in El Dorado County is much too steep to allow usage of a supply ditch. Water from a pipe line is run down a portable V flume—and fed to the furrows, as desired, from one-inch holes in the side. Control is maintained by small slide gates covering the holes on the outside of the flume. Rocks are placed in the flume below each opening, so that they allow a small pool to form, expediting the flow from the hole. Note, too, the small boards placed to prevent water splashing from the flume as it hits the rocks. The flumes are easy to construct and easy to move.

Irrigation Water Supply

The main irrigation system for this orchard (below) is a series of concrete pipe lines. The furrows between them are quite long. When the ground has been newly cultivated, as shown, the entire length of the furrow cannot be irrigated without causing some erosion because of the large stream necessary. To avoid such difficulty, this owner has built a portable box flume. It is placed in the orchard about halfway between the pipe lines. Thus smaller heads can be run from both the pipe lines and the flume. (The flume is in sixteen-foot lengths, with the bottom board of each tapered so sections telescope.) Note the remnants of the recent covercrop which has been worked into the surface soil.

FURROW IRRIGATION

An Excellent "Zigzag" Protective System

This walnut orchard in Los Angeles County has been prepared for irrigation with a very effective, yet seemingly complicated, furrow system. The furrows "going away" from your vision were prepared first, across the slope, and practically level. Those going from left to right in the photograph were made, using a blocking device, so that the water *zigzags* through the orchard. This method can be used when the slope is as much as three or four per cent. The slope illustrated, however, is somewhat less.

Because of cultural operations, it is necessary to prepare these furrows at least twice each year—once for protection against winter storms, and again for summer irrigation. After harvest, a covercrop is volunteered or sown, and the furrows are reworked. The covercrop and the furrows adequately protect the orchard against erosion, which frequently results from heavy run-offs caused by storms. The covercrop is worked into the soil in the spring, and the system is prepared once more for summer irrigation. If weeds grow too vigorously, the orchard may have to be disked and furrowed during the summer.

This is one of many effective systems that can be used in stepping water down slopes without danger of washing.

Steep-Slope Irrigation on Adobe Soil

Here is a grove of orange trees, planted in adobe soil, with a slope of about six per cent. On drying, the soil cracks very badly. This latter factor eliminates the use of any form of contour irrigation, because contour furrows just would not hold the water. If furrows are used at all, it is recommended that they run straight downhill. Small heads, run for a considerable time, give a satisfactory irrigation and avoid erosion.

The upper photograph shows the metal supply pipe line at the left, with the nozzles projecting toward the orchard. The lower photograph illustrates cracking of the adobe soil.

FURROW IRRIGATION

Suggestions for Improving This Orchard's Irrigation

As can be seen, the Bartlett pear tree shown is stunted. The irrigation furrows have cut deeply into the soil, which is about two feet deep on bedrock. Even if they had not, they would still be inadequate to wet the entire soil mass. This side-hill orchard could be irrigated successfully by any of these methods:

1. *Contour Furrows* run across the slope on a grade of about one and one half per cent. (At right angles to those shown in the photograph.) Two furrows to the row would be sufficient, because the water would penetrate to the bedrock, seep down the slope, and wet all of the soil.

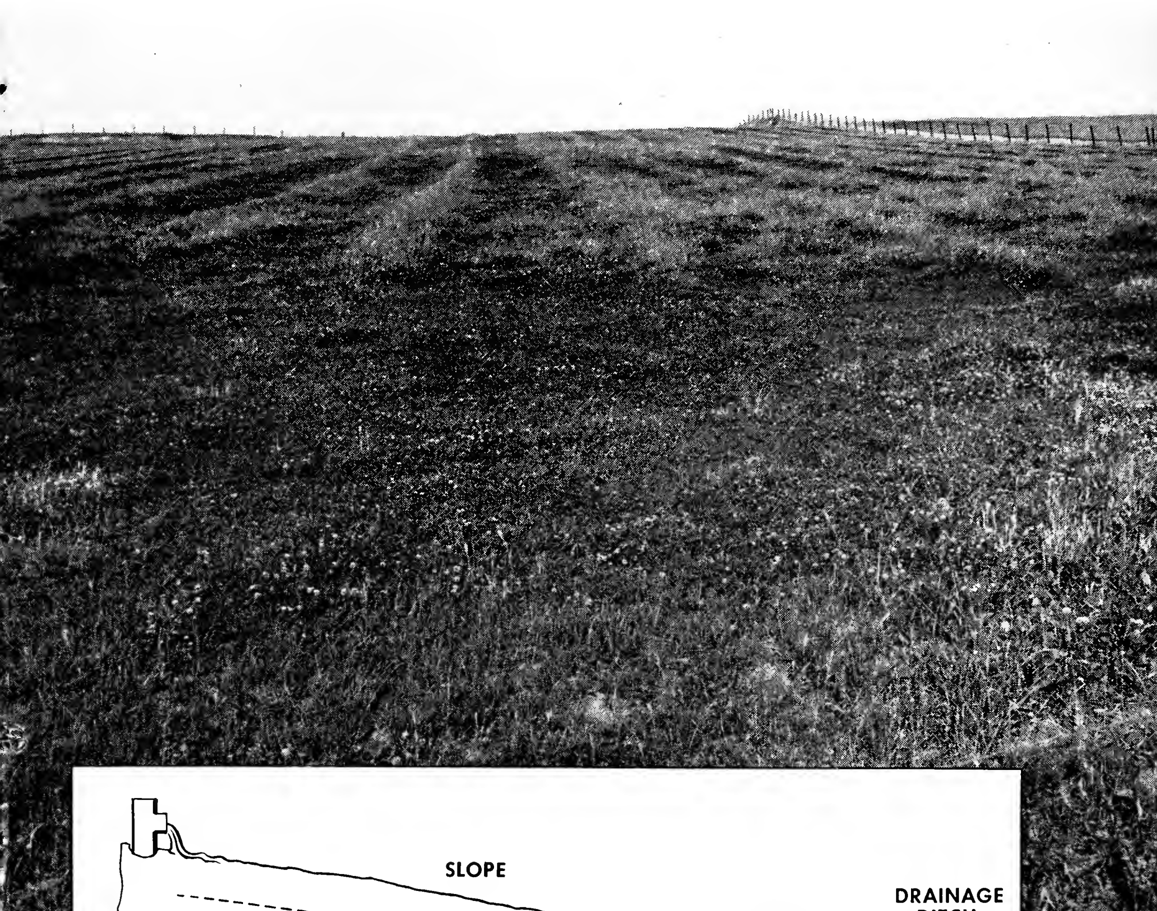
2. *Contour Ditches*, as shown on page 16, could be employed in this orchard at intervals of about 60 feet. The orchard should then be planted to permanent cover. Irrigation water could be spilled over the bank of the ditch every few feet to guarantee complete wetting of the soil.

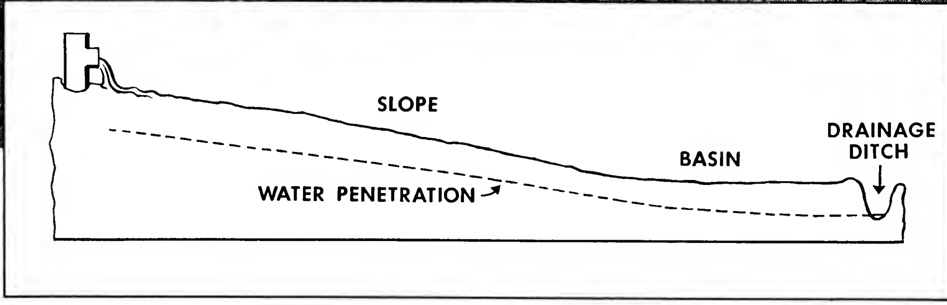
3. *Sprinklers* and a permanent cover-crop would be very effective. (See page 18 for details.) However, if most of the orchard can be successfully irrigated by furrows, as described in paragraph one, above, the latter would be a more practical solution to the problem. Small, steep, isolated areas are best handled this way.

STRIP CHECKS OR BORDERS

Clever Adaptation to Prevent Wasting Water

Most irrigated pastures are planted on soils with hardpan or dense clay subsoils. The Ladino clover pasture shown below is an excellent example of a relatively new method of land preparation for the maximum usage of irrigation water. Formerly the land was graded so that the strip checks ran all the way to the drainage ditch. The length of time necessary to run the water in the strip checks in order to get good penetration often resulted in great waste. The new method of leveling is shown in the sketch below. The ridges extend only to the basin. The excess water from the checks irrigates the basin, shown in the foreground of the photograph. The small amount of excess water runs into the drainage ditch.





CONTOUR DITCHES

Successfully Irrigated Pasture

Rather steep land can be utilized for irrigated pastures if proper methods are used. The technique pictured and described here is a very simple and very successful one.

The photograph shows a ditch with a grade of about one half of one per cent. The water spills over the lower edge. Excess water collects in the next ditch which is usually about 75 feet below, supplementing irrigation water in the second ditch, and so with others down the grade. Judgment must be used to assure complete irrigation; ditches must be spaced close enough to wet the entire area.

on Hillsides

The pasture shown in the photograph below is a good example of the use of contour ditches. Note how the dry pasture at the crest of the hill contrasts with that irrigated. The light patches in the right center of this picture indicate dry areas—the probable result of the ditches being too far apart to wet the entire area.

Orchards, too—

Deciduous orchards can also use this irrigation method in conjunction with a permanent covercrop. Under these conditions, however, the ditches must be steeper, because the unpastured vegetation tends to clog them.

Caution

should be exercised when permanent covercrops are used in orchards. Gophers become a problem, as it is not easy to detect their workings. Field mice sometimes build nests at the bases of trees, and girdle them. The rodent problem should be given consideration before the adoption of a permanent covercrop program.

SPRINKLER IRRIGATION

Sprinkler System Replaces Furrows in Pear Orchard

From clean cultivation and irrigation by furrows, a Placer County orchardist switched to permanent covercrop and sprinklers. The orchard is on a slope of about five per cent, with soil about twenty-two inches deep on bedrock. Result of the old system was uneven application of irrigation water and soil erosion. The new technique has proved very successful.

Irrigation water is delivered at a high point, so pumping is unnecessary to develop pressure. The water is distributed through an underground three-inch pipe, equipped with outlets for the portable sprinkler line.

Each irrigation starts at the upper edge of the orchard, with the portable line moved progressively downhill—wetting every other middle. When the lower edge of the orchard has been irrigated, the sprinkler line is moved once again progressively up the hill, and the alternate middles are irrigated. Thus complete wetting is accomplished.

The covercrop is predominantly Ladino clover, ryegrass, and orchardgrass. It is mowed and left in place each year just before the props are put in the orchard. Once again, caution is advised with regard to careful control of rodents who may take up habitation in the covercrop.

BASIN IRRIGATION

Methods Used for Irrigating Young Fruit Trees

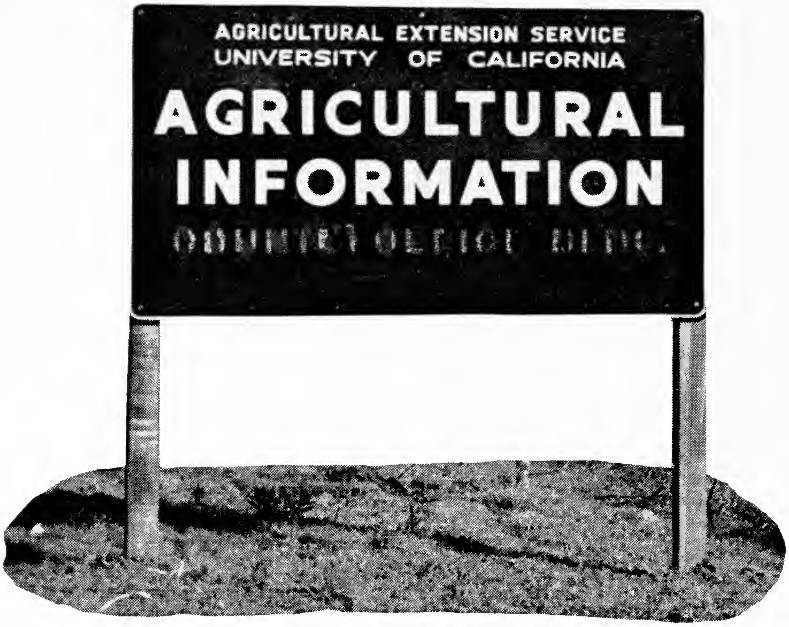
During the first few years after planting, the root systems of trees do not develop to the point where they occupy the entire soil mass in an orchard. It is unnecessary, therefore, to irrigate the middles of the rows during this period.

Tanking—shown in the top photograph—is simply the use of a circular basin around the tree, and watered as indicated. A long narrow basin is shown below, and the photograph explains this second method pretty well. A third technique is the running of a single furrow close to the tree rows, with a circular furrow around each tree.

As the root systems enlarge each year, the irrigated area for each tree should be increased. Generally, such partial irrigation should not be used more than two or three years for most trees. Widely spaced walnut trees, as shown in both photographs, can be wetted in this fashion for a longer period, however.

Caution: Citrus and avocado trees should not be treated so that the irrigation water comes into direct contact with their trunks. Nor should the earth be mounded against the trunks. A circular basin, with the inner margin a few inches from the tree, is recommended.

SIGNPOST FOR THE FUTURE—



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